The Sarana Programming Architecture to Support Applications on Large, Spatially Distributed Data

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Evolution of Handheld Devices

- Communication tool
- General-purpose computing platform
  - Cameras
  - GPS
  - Temperature sensors
  - Communication (internet, email)

A New Opportunity?
Dynamic Networks: Sharing & Opportunistic Collaboration

Dynamic Networks Applications

Collaborative computing
Exploiting multiple services

Sensor data collection/processing
QoR vs. resource consumption tradeoff

Green data/computing clouds
Fewer power, thermal, and environmental issues

Augmented-reality gaming
Physical world attached with virtual information

Sarana Project
Space-Aware and Resource-Aware Network Architecture

Enable Effective Programming of Dynamic Networks

Location awareness
In-network data processing and result distribution
Move computation to data (data centric)
Opportunistic resource sharing
  → accountability through cost models
  (application centric vs. node/network centric)
  → allow for tradeoff specifications
import SpaceDefs.Rutgers;

public class AverageLighting {
    public static void main(String[] args) {
        spatialview v = LightSensor @ Rutgers.CampusB;
        sumreduction float s = 0;
        sumreduction int n = 0;
        visiteach x : v {
            s += x.read(); n++;
        }
        if (n > 0)
            System.out.println(Float.toString(s / n));
        else
            System.out.println("No sensor found.");
    }
}

• A spatialview defines a set of interesting nodes
• A visiteach defines a parallel execution of iterations on discovered, interesting nodes

Possible Projects
Space-resilient services
Energy and resource-aware security mechanisms
Quality of Result tradeoff specifications
Evaluation of Sarana architecture to support service cloud
Development of dynamic network applications benchmark suite

Space-Resilient Services

candidate service host

service host
Space-Resilient Services

target area

candidate service host  service host

Deliverables

0 - 6 months
- Language features to express service resilience in Sarana
- Dynamic installation and registration of services
- Mobility model for Sarana simulation environment
- Basic decision policies for service host selection

7 - 12 months
- Evaluation of prototype implementation
- Push vs. pull code distribution
- Refinement of service host selection policies
- Physical measurements and evaluation

12+ months
- Low cost / high latency code and data dissemination through space-aware services
Is a red four-door sedan in my vicinity?

All phones reply “yes”

How to trust the results of remote computations?

Participating devices equipped with a Trusted Platform Module (TPM)

Launchees and Launcher engage in an Integrity Measurement Protocol

Trusted Computing for Mobile Devices

Prove to me that your software stack is not malicious

Compute hash chain (H) and metadata (M) about software stack

Digitally sign H and M

Send H and M

Verify Integrity

Integrity Measurement Protocol
Deliverables

0 - 6 months
- Implement integrity measurement protocol for Sarana VM
- Measure overheads: execution time, data, bandwidth, energy
- Explore energy efficient modifications to protocol.
  - Asynchronous attestation (Jaeger ACSAC’09)
  - Batch and reuse integrity computations

7 - 12 months
- Evaluation of prototype implementation, with focus on security level / energy tradeoffs
- Extend approach to Sarana VM applications
- Refine initial designs if necessary

12+ months
- Protection against malicious client code (sandboxing)
- How to trust sensor readings?

Thanks
Project Name: The Sarana programming architecture to support applications on large, spatially distributed data

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Description:
Mobile devices such as smart phones have become general purpose programming platforms with significant computation, data, and communication capabilities. Smart phones may collaborate in an opportunistic fashion in order to execute a spatiotemporal application, such as tracking a person in an airport terminal, or storing large data sets scattered across their local memories. In contrast to most sensor networks, dynamic network nodes may join or leave the network at any time, i.e., the program has no control over the target platform. We have developed the Sarana programming architecture for space- and resource-aware applications for dynamic networks. Nodes can be addressed by the services that they provide (e.g.: camera, specialized software, data storage), and their locations. Sarana provides a data and application centric programming model where program accountability is ensured through a resource cost models.

We will address two issues in programming dynamic networks, namely (1) space-resilient services and (2) energy-efficient, trusted computing. A space-resilient service is deployed within a user-specified target area, and tries to stay within this area. If its host moves, the service will need to migrate to a new host within the target space. Clearly, security is a crucial concern in an opportunistic environment where owners of smart phones are willing to share some of their phones’ resources. We will investigate different strategies for space-resilient services and trusted computing. We will implement and evaluate the new strategies within our Sarana prototype system.

Experimental Plan:
- Fall 10: Design and implementation of basic strategies within the Sarana programming infrastructure
- Spring 11: Evaluation of strategies, and refinement of strategies based on the evaluation results

Related Work Elsewhere:
- Marco-programming in sensor networks
- Integrity measurement protocols for non-mobile, energy oblivious systems

How Ours Is Different:
- New programming abstraction for space-resilient services
- Energy-aware integrity measurement protocols and the investigation of their security / energy tradeoffs
- Evaluation of prototype systems through simulation and physical measurements

Related Work in Center:
- Vision and data analysis applications that can be performed efficiently in-network

Milestones:
- end 2010: Working prototype systems
- summer 2011: Evaluation of different strategies based on their efficiency in terms of reliability, security and energy

Deliverables:
- Technical demonstration along with a technical reports resulting in publications; reference implementation in Sarana

Budget: $100,000

Potential Benefits to Member Companies:
- Getting effective access to the vast resources provided by millions of smart phones worldwide